

## WHAT IS CLAIMED IS:

1. A catalyst for trimerization of ethylene which comprises:

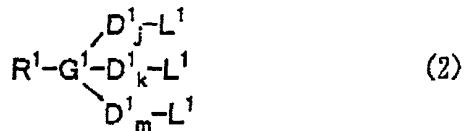
(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



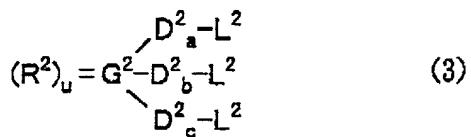
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M, and

(ii) an alkylaluminoxane;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



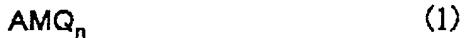
wherein j, k and m independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not concurrently a substituent containing an element an element of group 14 or 17,  $G^2$  represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and  $R^2$  represents an oxygen or sulfur atom.

2. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):

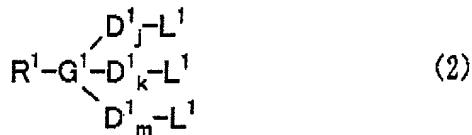


wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M, and

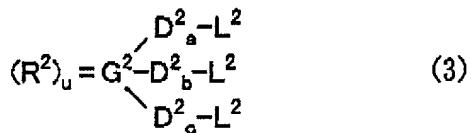
(ii) an alkylaluminoxane, and

(iii) a halogenated inorganic compound;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein  $j$ ,  $k$  and  $m$  independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein  $a$ ,  $b$  and  $c$  independently represent an integer of 0 to 6;  $u$  represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^2$  represents a nitrogen or phosphorus atom when  $u$  is 0, or a phosphorus atom when  $u$  is 1, and  $R^2$  represents an oxygen or sulfur atom.

3. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



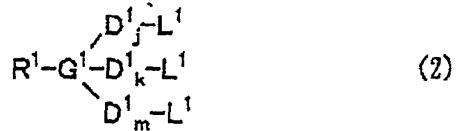
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

- (ii) an alkylaluminoxane,
- (iii) a halogenated inorganic compound, and
- (iv) an alkyl group-containing compound represented by the following formula (4):



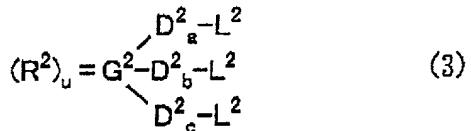
wherein p and q are numbers satisfying the formulae:  $0 < p \leq 3$  and  $0 \leq q < 3$ , provided that  $(p + q)$  is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three

$L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^2$  represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and  $R^2$  represents an oxygen or sulfur atom.

4. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

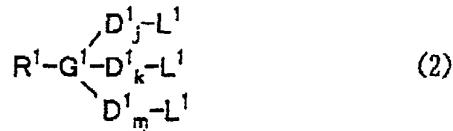
(ii) an alkylalumininoxane, and

(iii) an alkyl group-containing compound represented by the following formula (4):

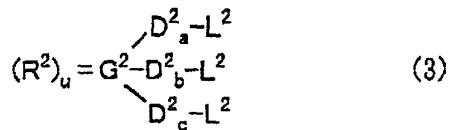


wherein p and q are numbers satisfying the formulae:  $0 < p \leq 3$  and  $0 \leq q < 3$ , provided that  $(P + q)$  is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to

6; u represents an integer of 0 or 1; each D<sup>2</sup> independently represents a divalent hydrocarbon group which may have a substituent; each L<sup>2</sup> independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L<sup>2</sup>'s are not concurrently a substituent containing an element an element of group 14 or 17, G<sup>2</sup> represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R<sup>2</sup> represents an oxygen or sulfur atom.

5. A catalyst for trimerization of ethylene which comprises:

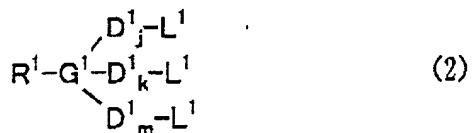
(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

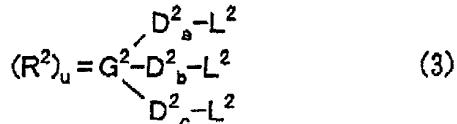
(ii) an alkylaluminoxane, and  
 (iii) at least one compound selected from the group consisting of an amine compound and an amide compound;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to

6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^2$  represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and  $R^2$  represents an oxygen or sulfur atom.

6. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon

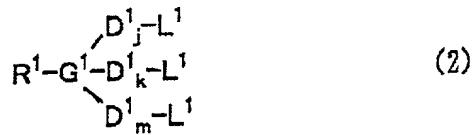
atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

- (ii) an alkylaluminoxane,
- (iii) at least one compound selected from the group consisting of an amine compound and an amide compound, and
- (iv) an alkyl group-containing compound represented by the following formula (4):



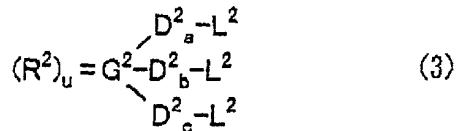
wherein p and q are numbers satisfying the formulae:  $0 < p \leq 3$  and  $0 \leq q < 3$ , provided that  $(p + q)$  is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6

to 10 carbon atoms which may have a substituent;



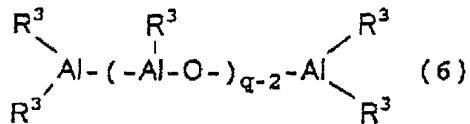
wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not concurrently a substituent containing an element an element of group 14 or 17,  $G^2$  represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and  $R^2$  represents an oxygen or sulfur atom.

7. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, wherein said organometallic complex having a neutral multidentate ligand having a tripod structure is an organochromium complex represented by formula (1) wherein M is a chromium atom.

8. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, wherein a neutral multidentate ligand having a tripod structure A is facially coordinated to a transition metal atom M of group 3 to group 10 of the periodic table in the organometallic complex of formula (1).

9. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, the alkylaluminoxane is at least one compound selected from the group consisting of compounds represented by the following formulae (5) and (6):





wherein each  $R^3$  independently represents a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms, and  $q$  is an integer of 2 to 60.

10. A catalyst for trimerization of ethylene according to claim 2 or 3, the halogenated inorganic compound is represented by the following formula (7):



wherein Z is an atom of group 1, 2, 13, 14 or 15 of the periodic table, X represents a halogen atom, and h denoting a number of X is a natural number equal to the formal oxidation valence of Z.

11. A catalyst for trimerization of ethylene according to claim 5 or 6, wherein each of the amine compound and the amide compound has at least one nitrogen atom having three substituents other than hydrogen atoms, and has 3 to 30 carbon atoms.

12. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 1 to 6.

13. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 1 to 6;

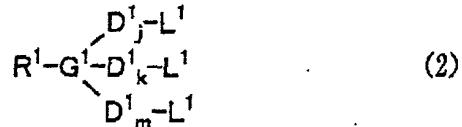
said catalyst being prepared by a step comprising placing (i) an organometallic complex having a neutral multidentate ligand having a tripod structure, in contact with (ii) an alkylaluminoxane in the presence of ethylene;

said organometallic complex having a neutral multidentate ligand having a tripod structure being represented by the following formula (1):

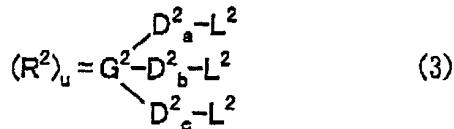


wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each  $D^1$  independently represents a divalent hydrocarbon group which may have a substituent, each  $L^1$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^1$ 's are not concurrently a substituent containing an element of group 14 or 17,  $G^1$  represents a carbon or silicon atom, and  $R^1$  represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



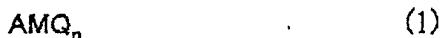
wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each  $D^2$  independently represents a divalent hydrocarbon group which may have a substituent; each  $L^2$  independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three  $L^2$ 's are not

concurrently a substituent containing an element an element of group 14 or 17, G<sup>2</sup> represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R<sup>2</sup> represents an oxygen or sulfur atom.

14. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 3, 4 and 6;

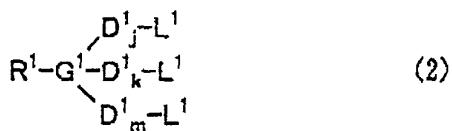
said catalyst being prepared by a step comprising placing (i) an organometallic complex having a neutral multidentate ligand having a tripod structure, in contact with (ii) an alkylaluminoxane and (iii) an alkyl group-containing compound in the presence of ethylene;

said organometallic complex having a neutral multidentate ligand having a tripod structure (i) being represented by the following formula (1):



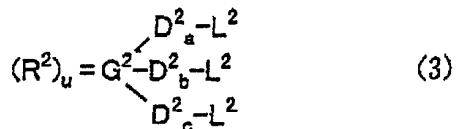
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D<sup>1</sup> independently represents a divalent hydrocarbon group which may have a substituent, each L<sup>1</sup> independently represents

a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L's are not concurrently a substituent containing an element of group 14 or 17, G<sup>1</sup> represents a carbon or silicon atom, and R<sup>1</sup> represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D<sup>2</sup> independently represents a divalent hydrocarbon group which may have a substituent; each L<sup>2</sup> independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L<sup>2</sup>'s are not concurrently a substituent containing an element of group 14 or 17, G<sup>2</sup> represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R<sup>2</sup> represents an oxygen or sulfur atom; and

said alkyl group-containing compound (iii) being represented by the following formula (4):



wherein p and q are numbers satisfying the formulae:  $0 < p \leq 3$  and  $0 \leq q < 3$ , provided that  $(P + q)$  is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom.